Parabolic Cylinder Analysis

Dave McGinnis
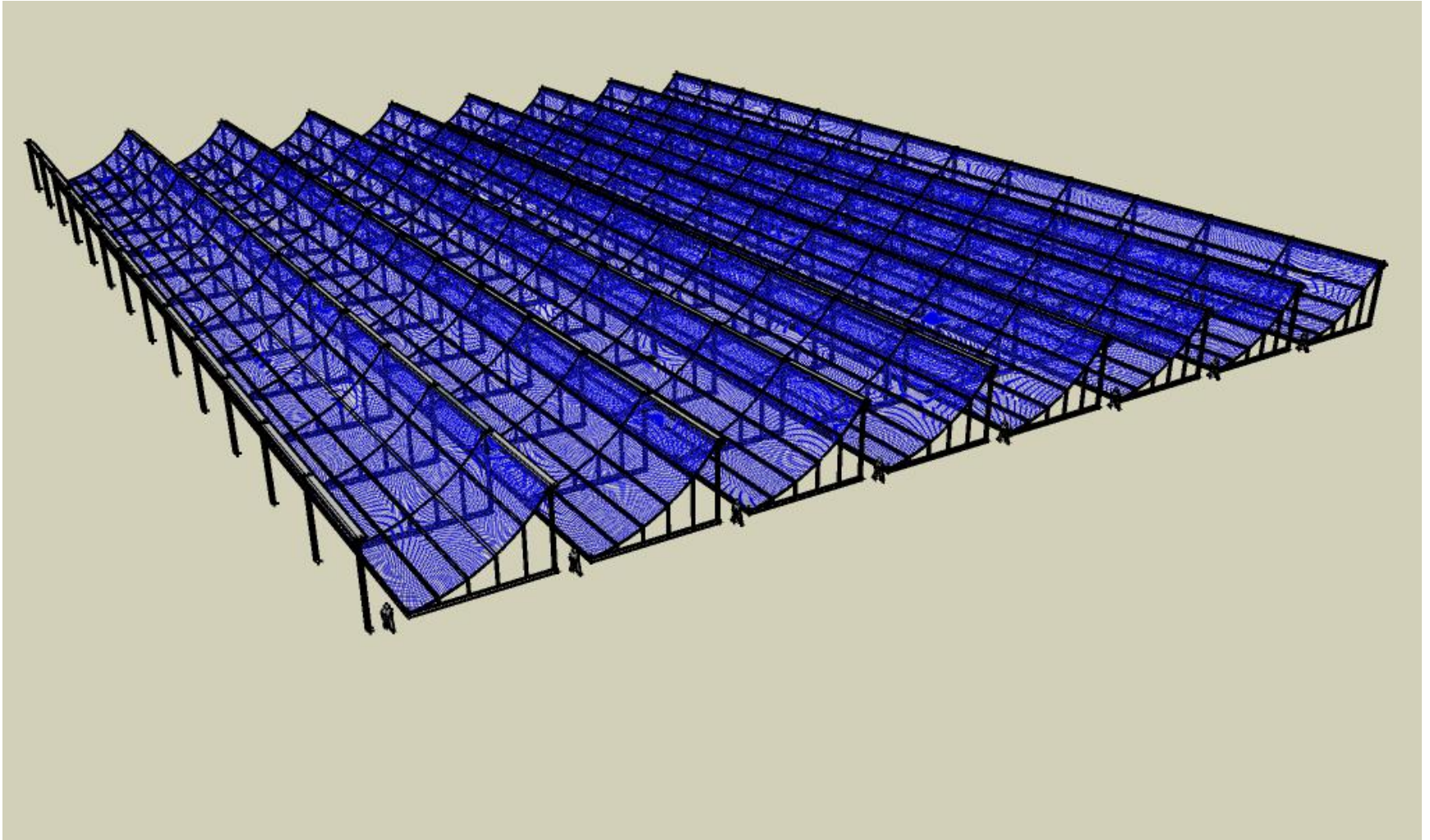
Fermilab

October 3, 2008
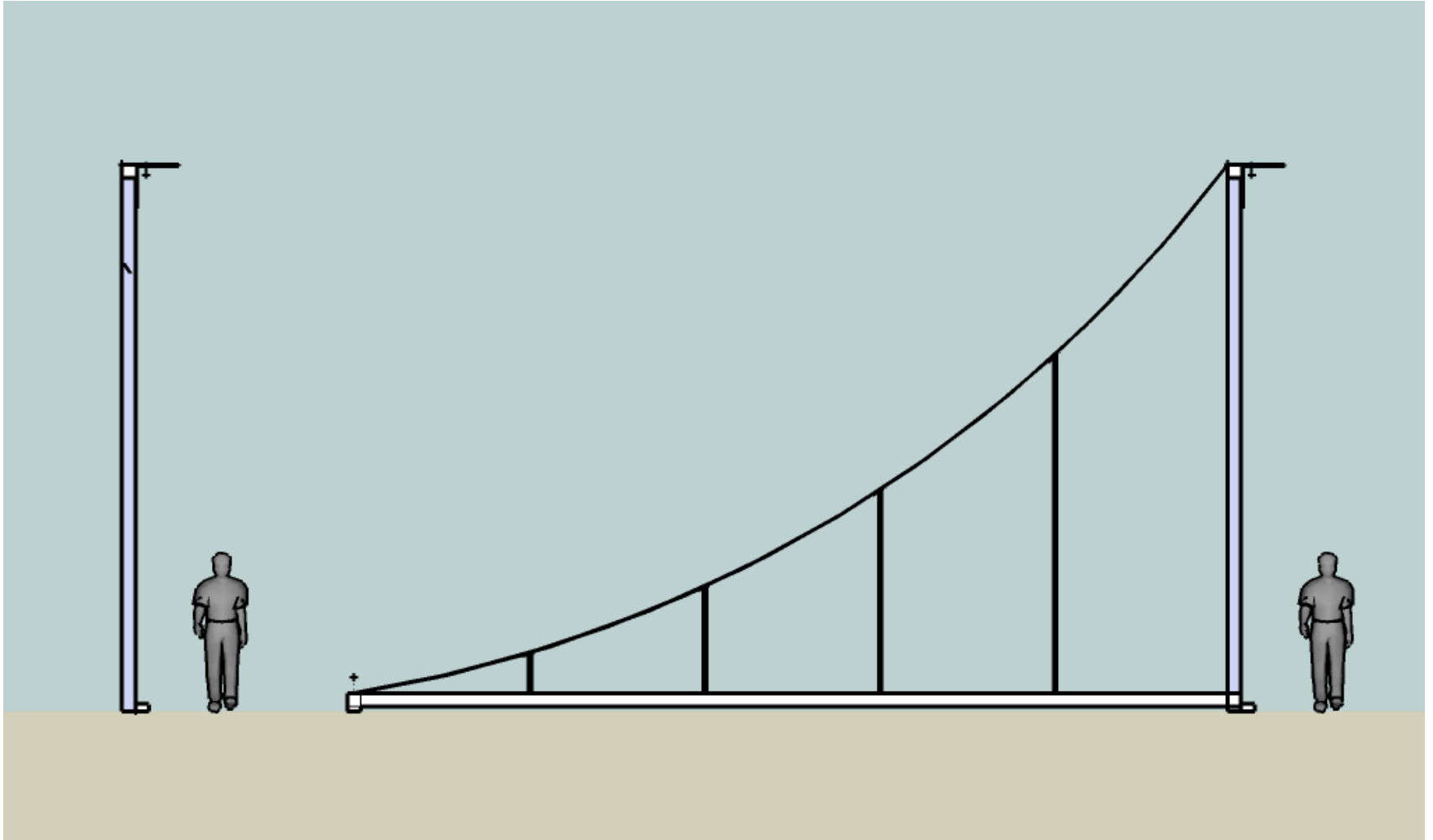
Design Parameters

- Number of cylinders = 8
- Cylinder length = 130 m
- Cylinder width = 12.5 m
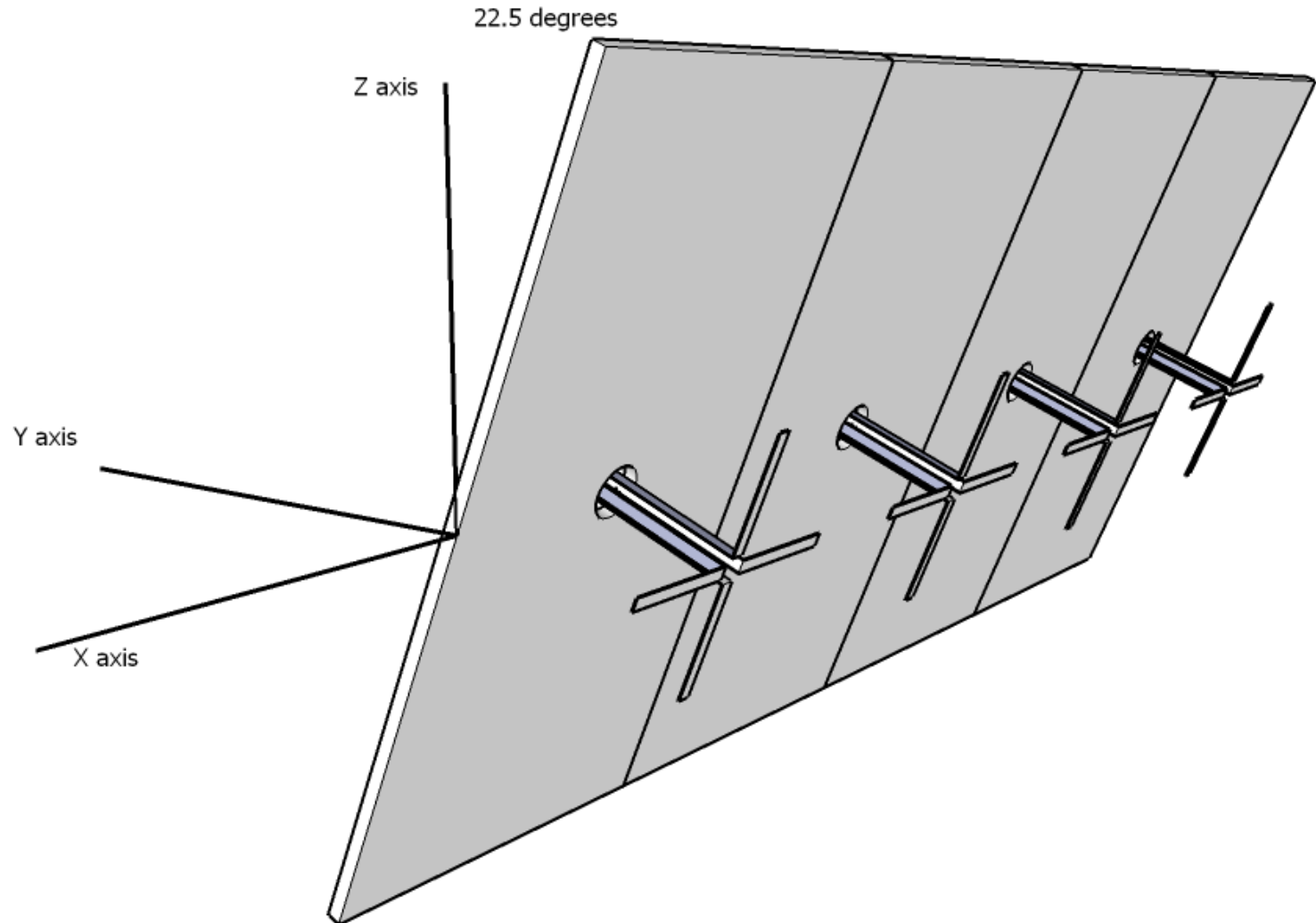- Cylinder Transverse beam width < 8 x 15 arc-min
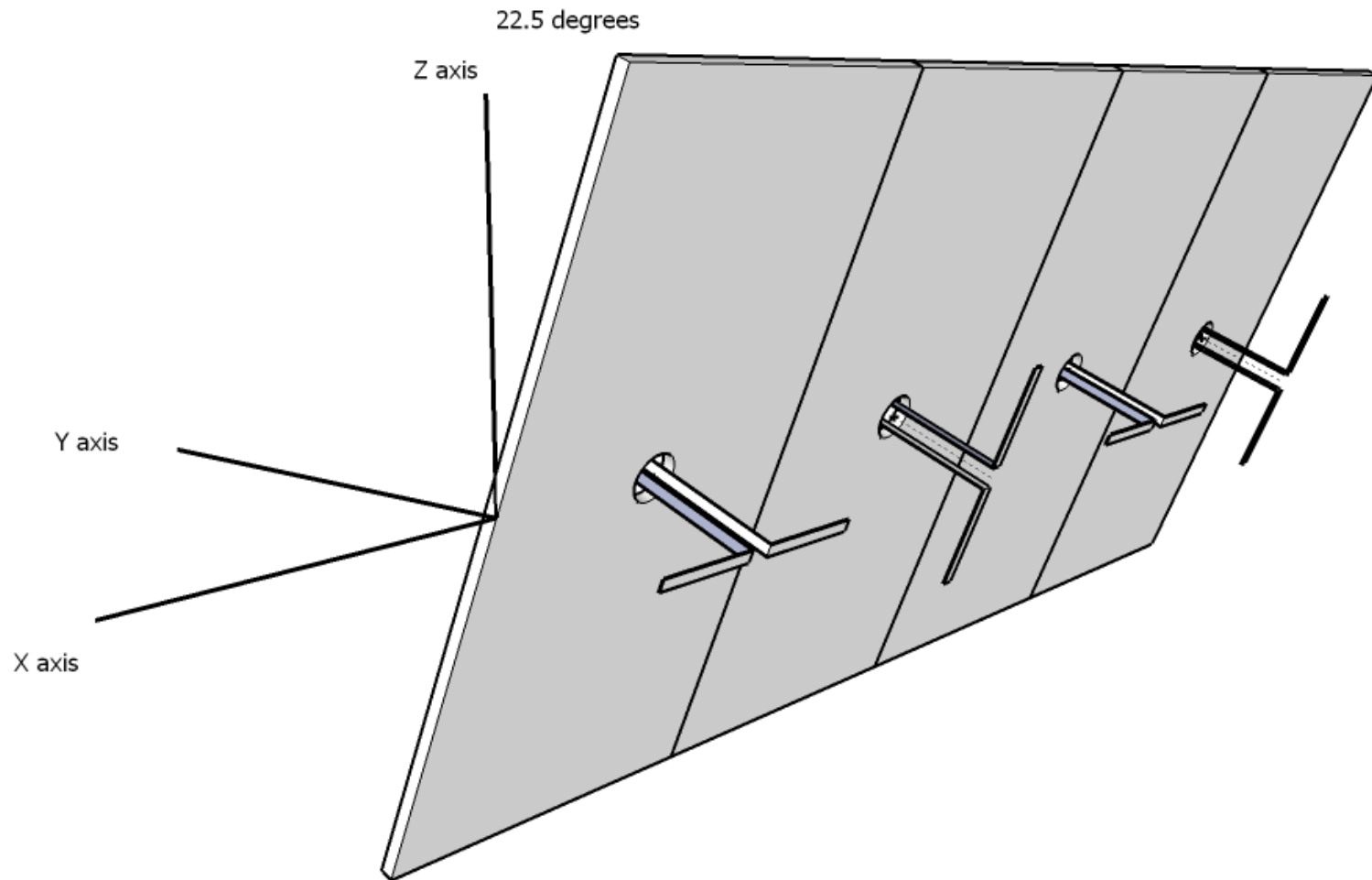
Telescope Layout

Cylinder Cross-Section

# Simple Telescope Feed
(first attempt)

Alternating Telescope Feed

Offset-Fed Telescope

- Concern about double bounce modulation between dish and feed will cause significant ripple in the antenna pattern.

- Would like feed to be hidden by dish to shield from RFI sources.

- Small f-ratio exaggerates focus errors
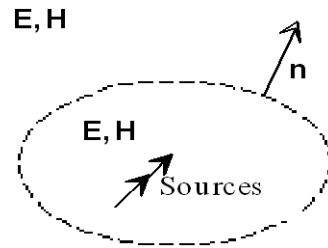 - Beam must be parallel to primary axis
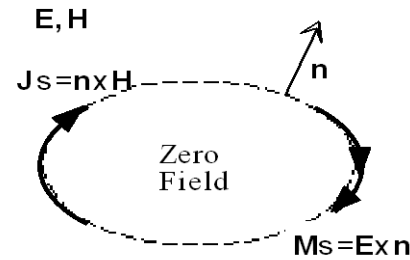 - Cut >50% of dish away

Offset-Fed Telescope
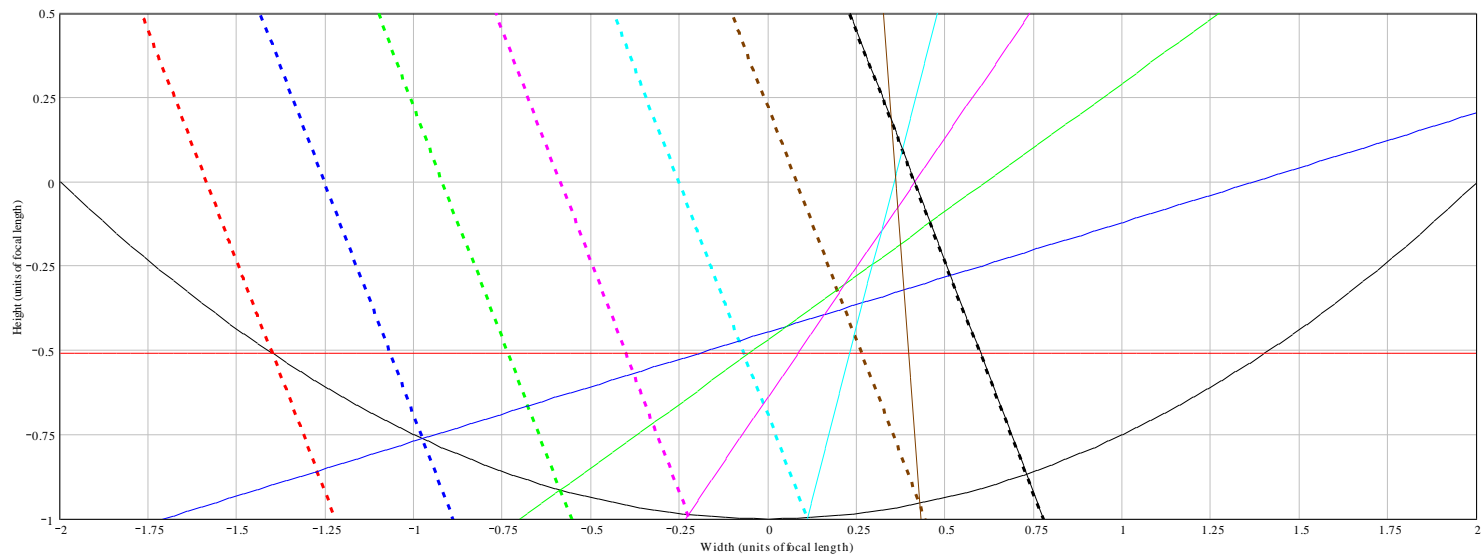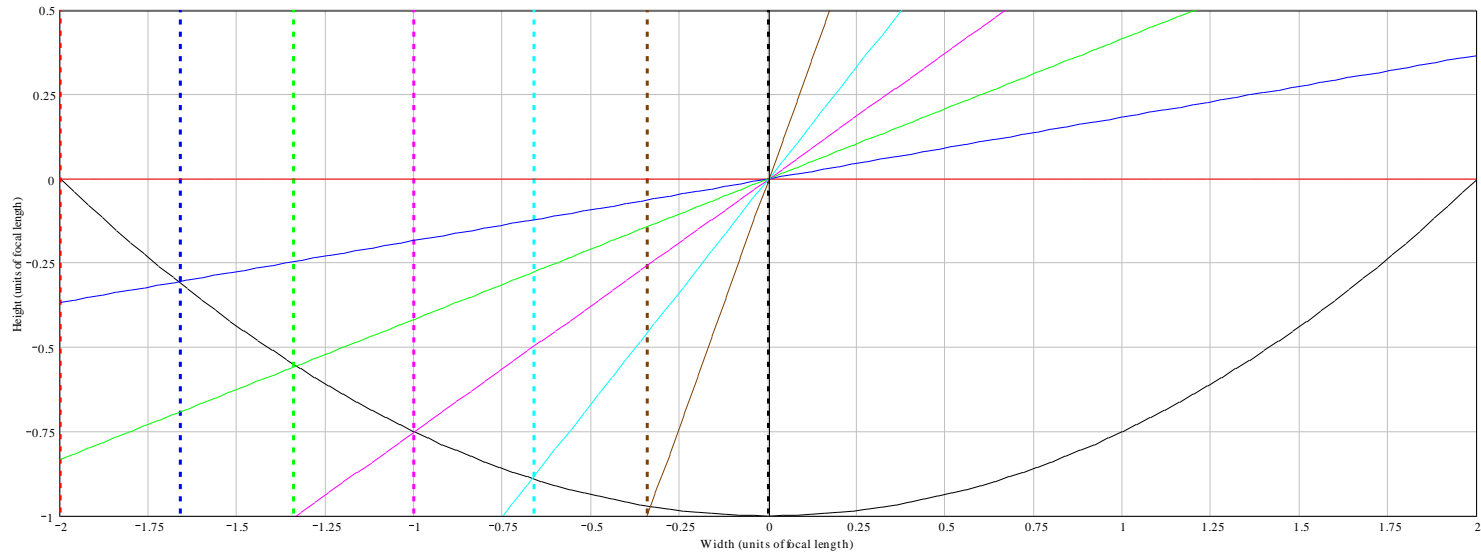
Cylinder Simulations

- Physical Optics Approximation

- The antenna dish reflects a scattered field so that the total tangential electric field on the dish is zero. $\vec{E}_{Total} = \vec{E}_{inc} + \vec{E}_{scat}$

- On the surface of the dish: $\hat{n} \times \vec{E}_{inc} = -\hat{n} \times \vec{E}_{scat}$

- If the incident field on the dish surface is known, then the scattered field on the dish surface is also known
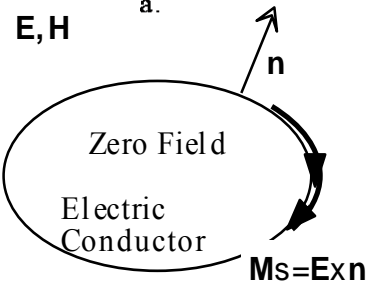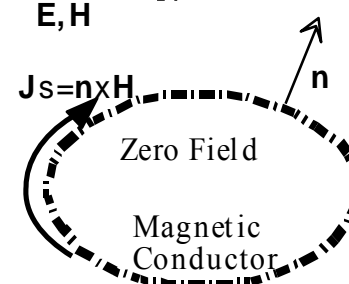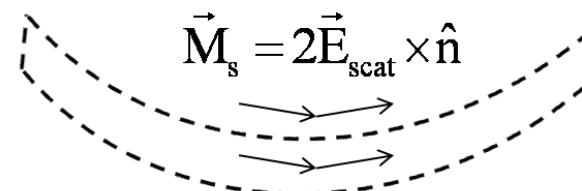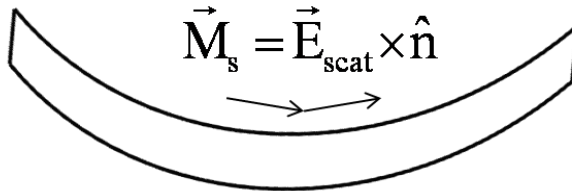
Physical Optics Approximation

E, H

n

E, H

Sources

a.

E, H

n

Zero Field

Electric
Conductor

Ms=Exn

a.

E, H

Js=nxH

n

Zero
Field

Ms=Exn

b.

E, H

Js=nxH

n

Zero Field

Magnetic
Conductor

b.

$$\vec{M}_s = \vec{E}_{scat} \times \hat{n}$$
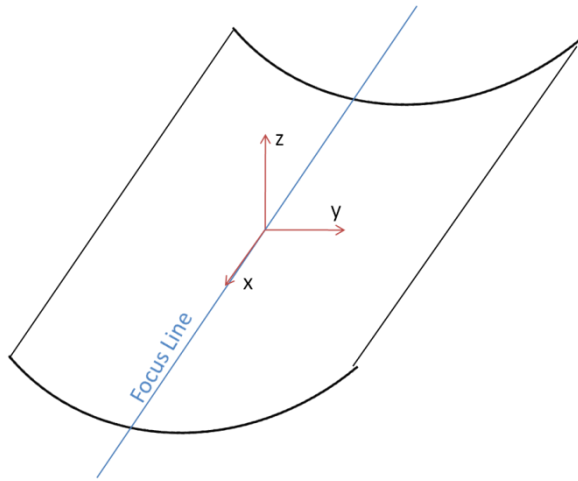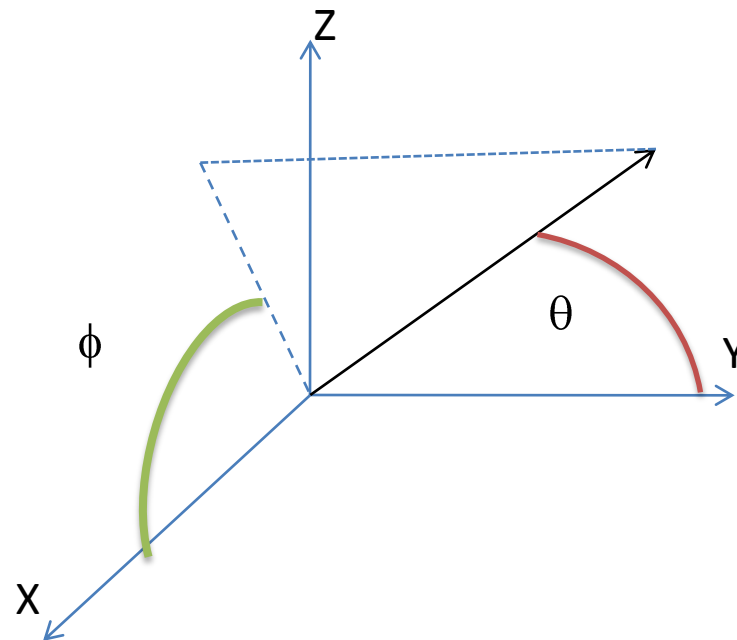
$$\vec{M}_s = 2\vec{E}_{scat} \times \hat{n}$$

Telescope Coordinate System

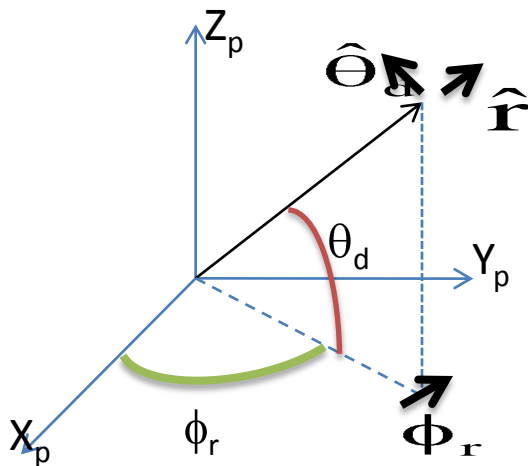$$D(\phi,\theta) = \frac{U(\phi,\theta)}{\frac{1}{4\pi} \iint U(\phi,\theta)\sin(\theta)d\theta d\phi}$$
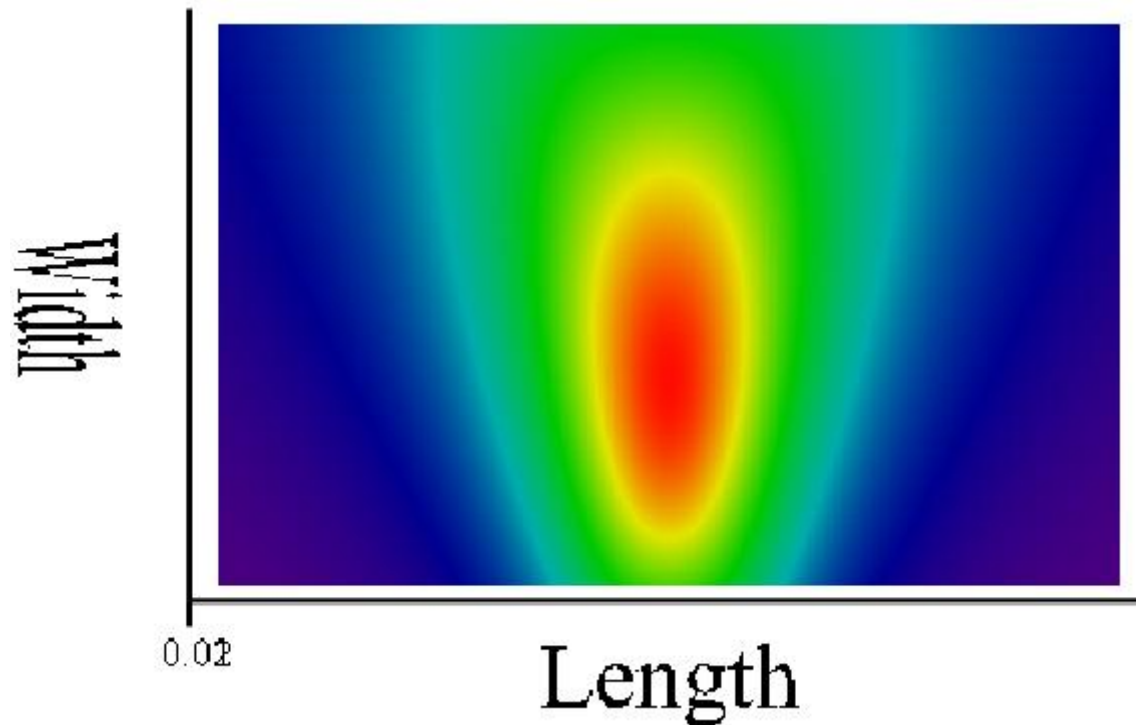
$$U(\phi,\theta) = \frac{1}{2}\operatorname{Re}\{\vec{E} \times \vec{H}^*\} \cdot \hat{r}R^2$$

Polarization
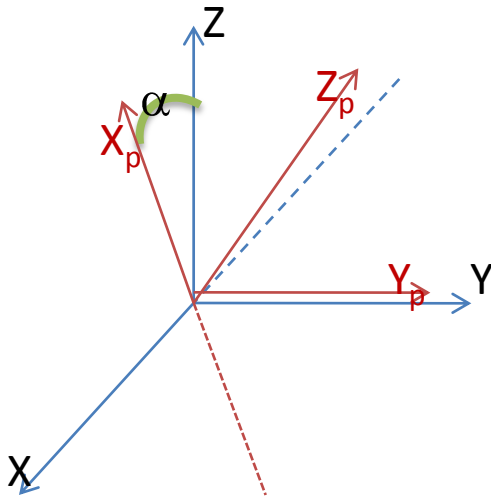
Celestial coordinate system (in red) with respect to telescope coordinate system. The angle a equal to the latitude of the telescope location

Celestial Coordinate system defined by declination angle, θ_d, and right ascension angle, ϕ_ρ.

$$\widehat{\theta_d} = \begin{aligned} &-\big(\sin(\alpha)\sin(\theta_d)\cos(\phi_r) + \cos(\alpha)\cos(\theta_d)\big)\hat{x} \\ &+\big(\sin(\theta_d)\sin(\phi_r)\big)\hat{y} \\ &+\big(-\cos(\alpha)\sin(\theta_d)\cos(\phi_r) + \sin(\alpha)\cos(\theta_d)\big)\hat{z} \end{aligned}$$

$$\widehat{\phi_r} = \begin{aligned} &-\big(\sin(\alpha)\sin(\phi_r)\big)\hat{x} \\ &+\big(\cos(\phi_r)\big)\hat{y} \\ &-\big(\cos(\alpha)\sin(\phi_r)\big)\hat{z} \end{aligned}$$

Directivity

$$D(\phi, \theta) = \frac{U(\phi, \theta)}{\frac{1}{4\pi} \iint U(\phi, \theta) \sin(\theta) d\theta d\phi}$$

$$\Omega_A = \frac{4\pi}{D_{max}}$$

$$A_{em} = \frac{\lambda^2}{\Omega_A}$$

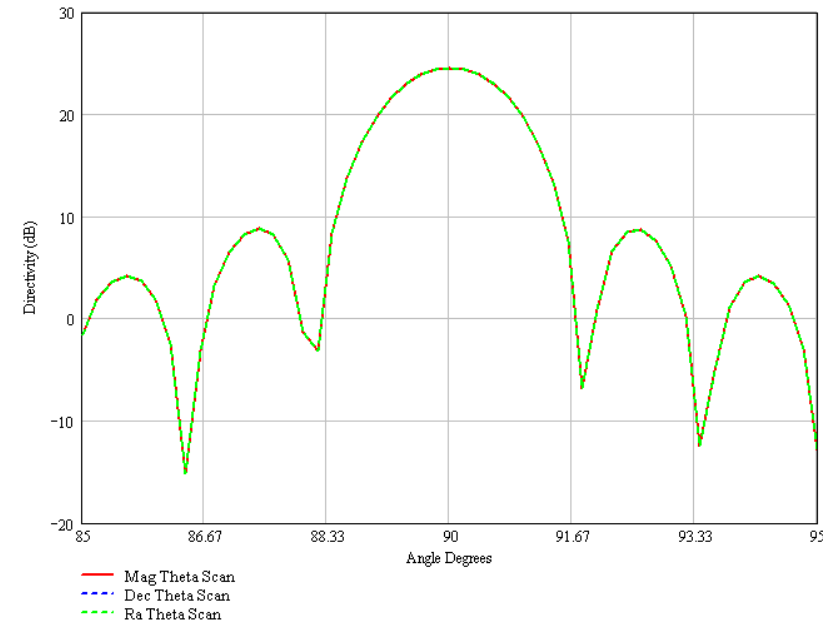$$L_{em} = \frac{A_{em}}{W}$$
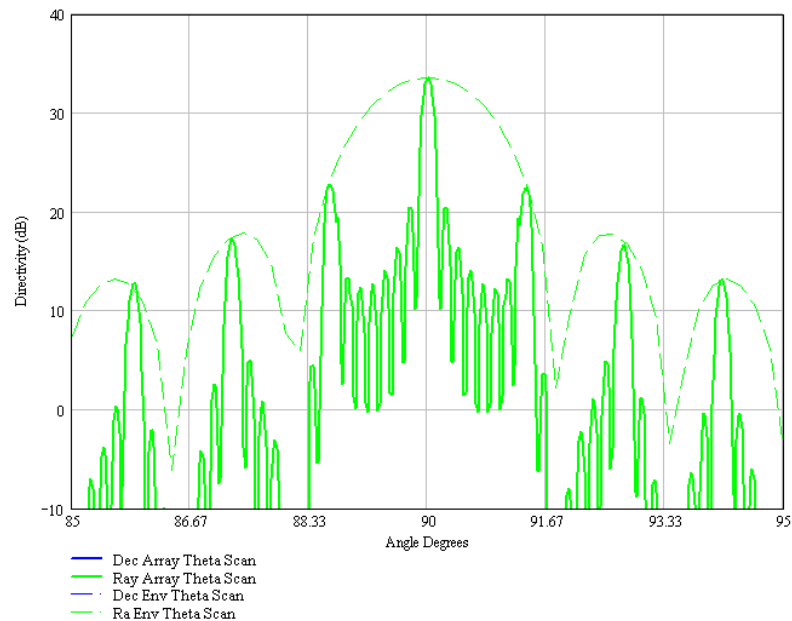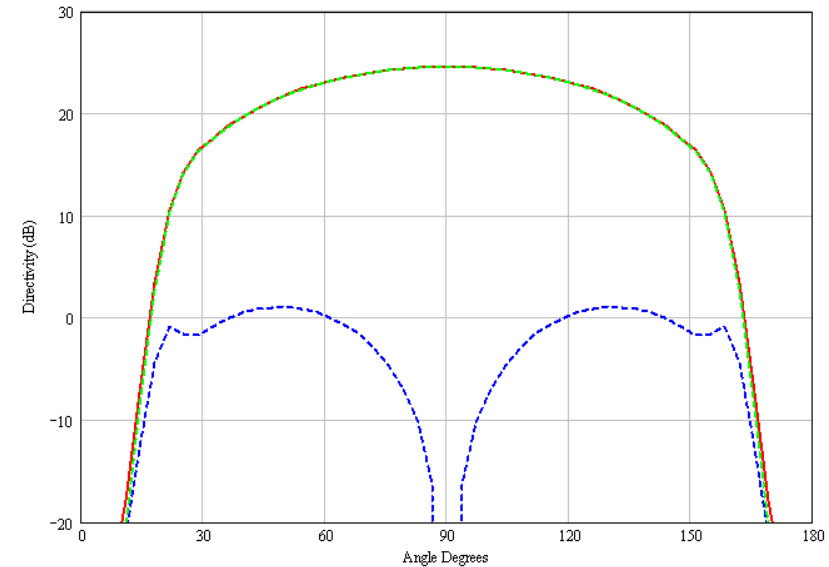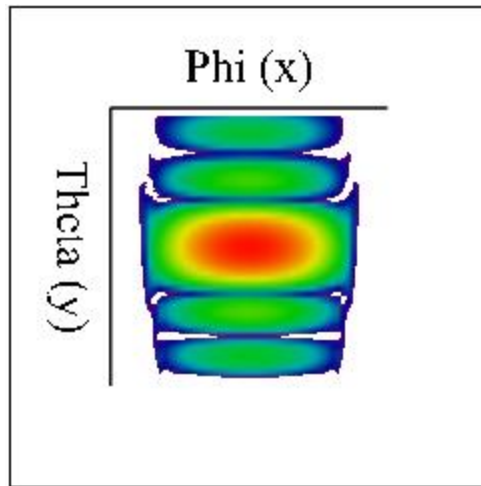
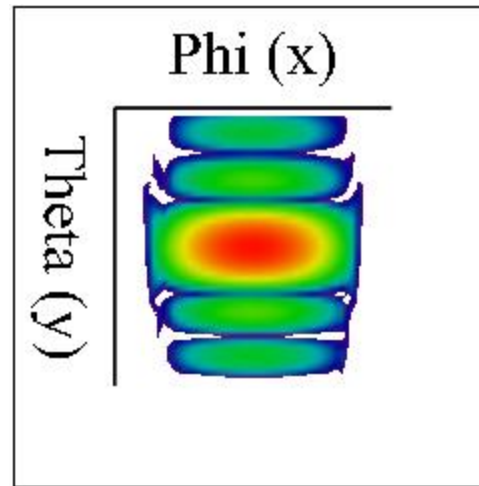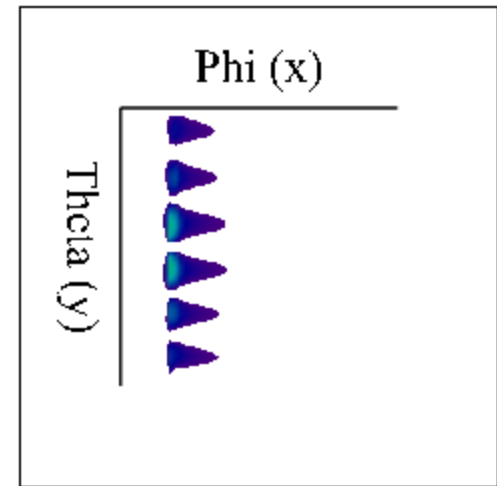# Y-Z Polarization Results
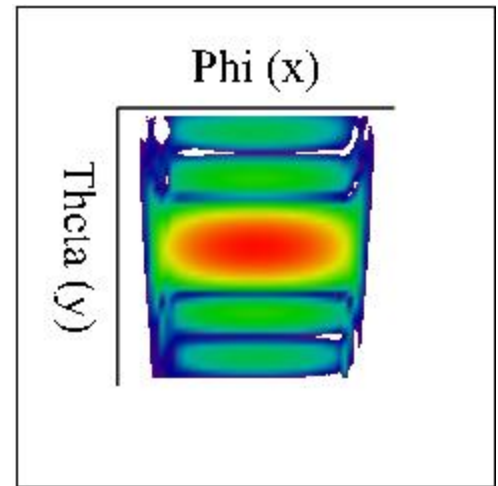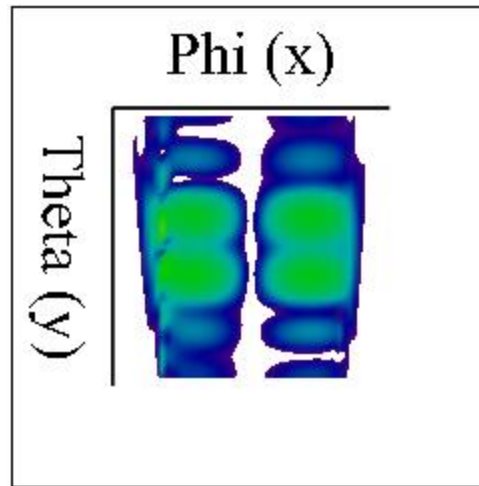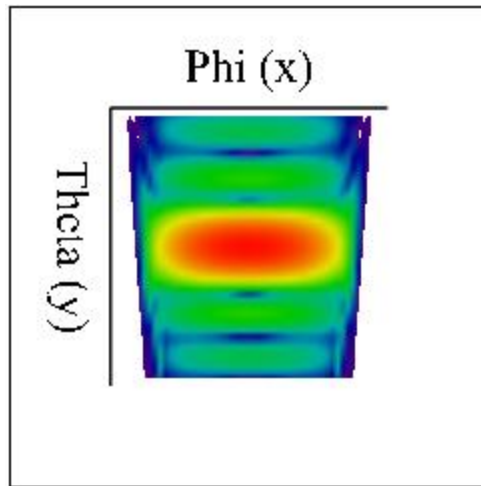
Y-Z Polarization Results

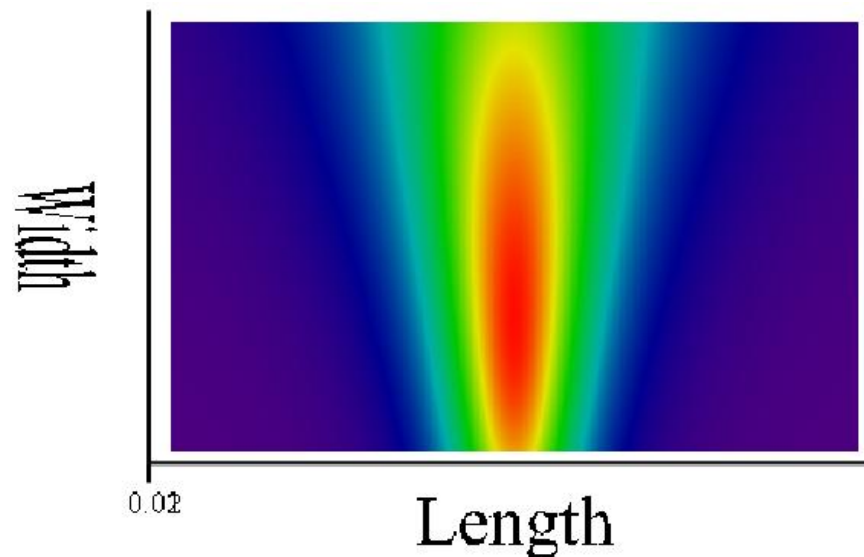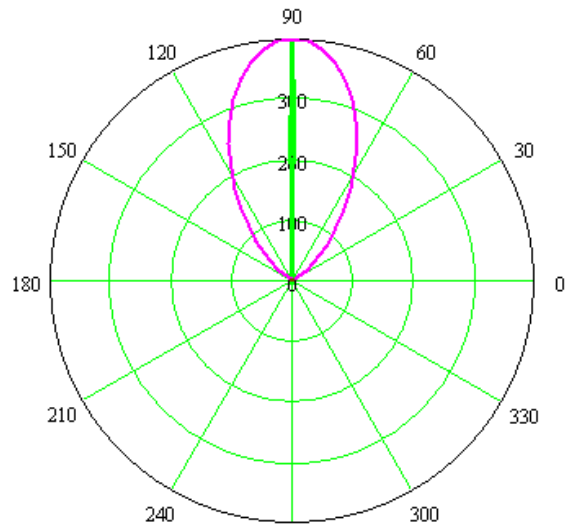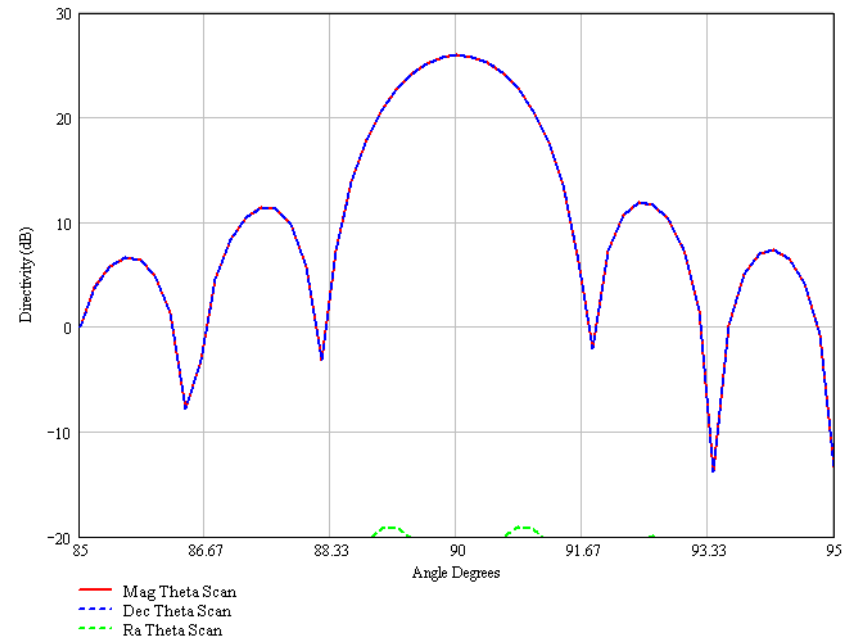$$\frac{L_{em}}{\lambda} = 0.687$$

X-Polarization Results

eMagLog

eDecLog

eRaLog

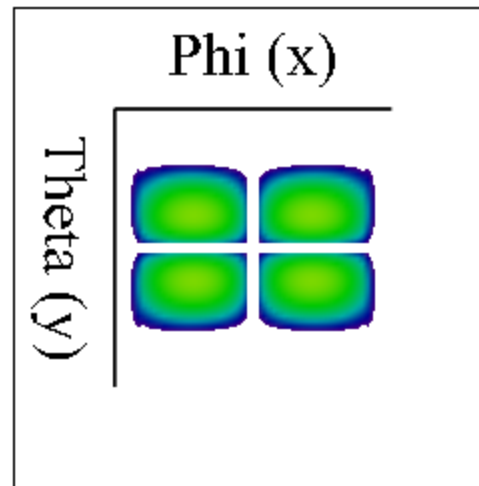# X-Polarization Results

$$\frac{L_{em}}{\lambda} = 0.944$$
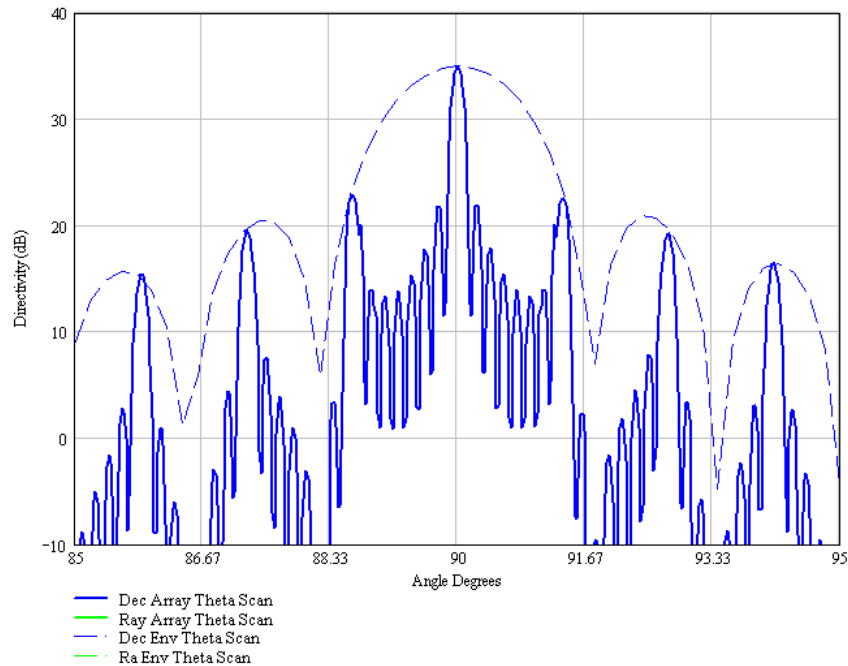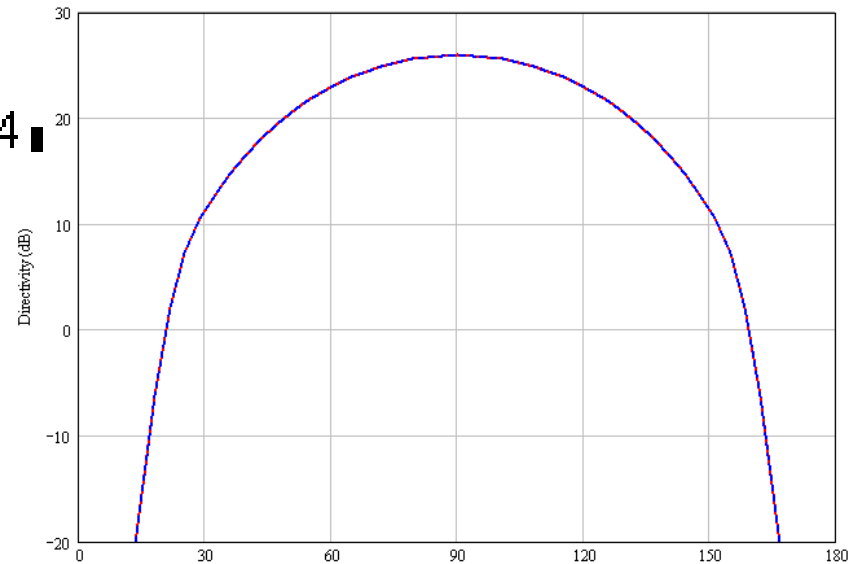
Future Work

- Explore other feed designs
  - Square patch antenna
  - Folded dipole
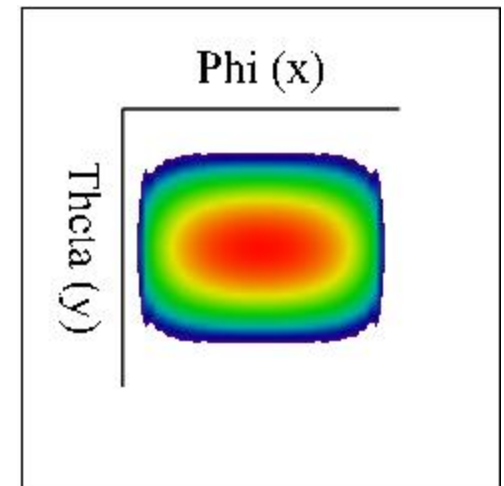- Moment Method simulation of feed to understand coupling
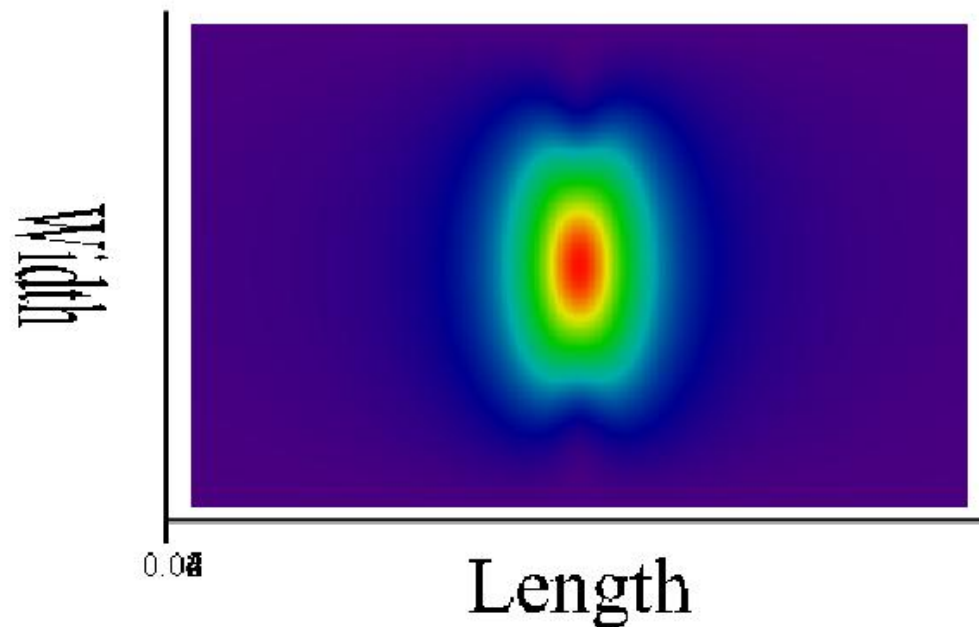- Explore larger f-ratio

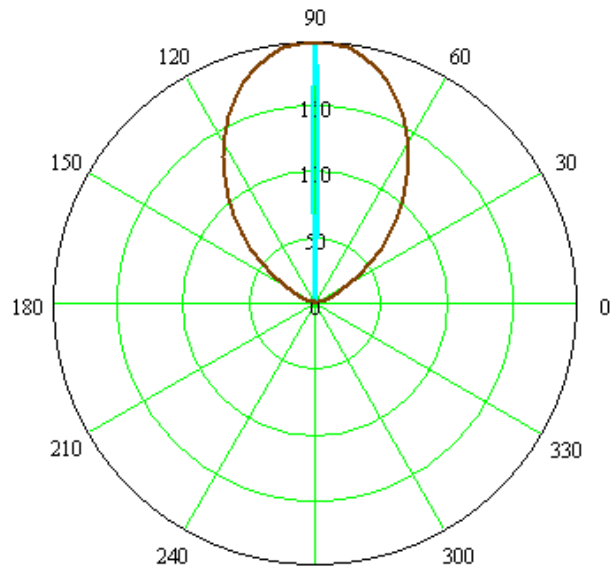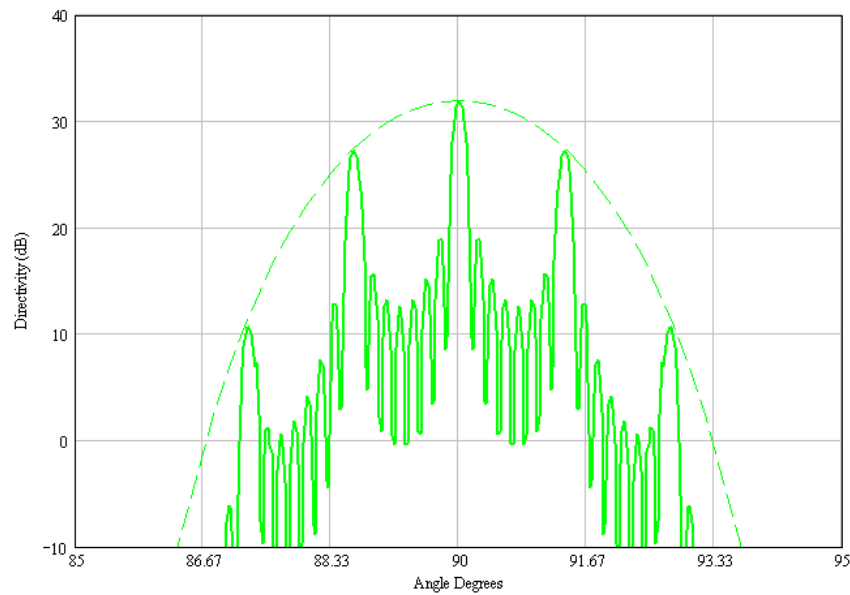# Y Polarization (Full Width)

eMagLog

eDecLog

eRaLog

0.00

Length

Width

Y Polarization (Full Width)

$$\frac{L_{em}}{\lambda} = 0.376$$

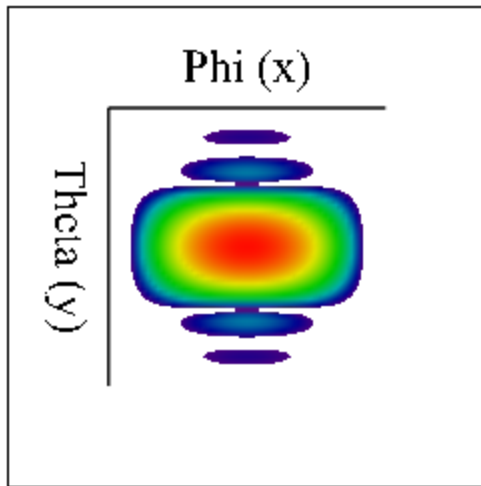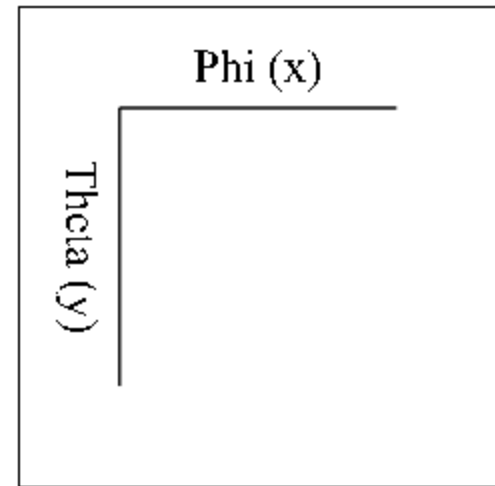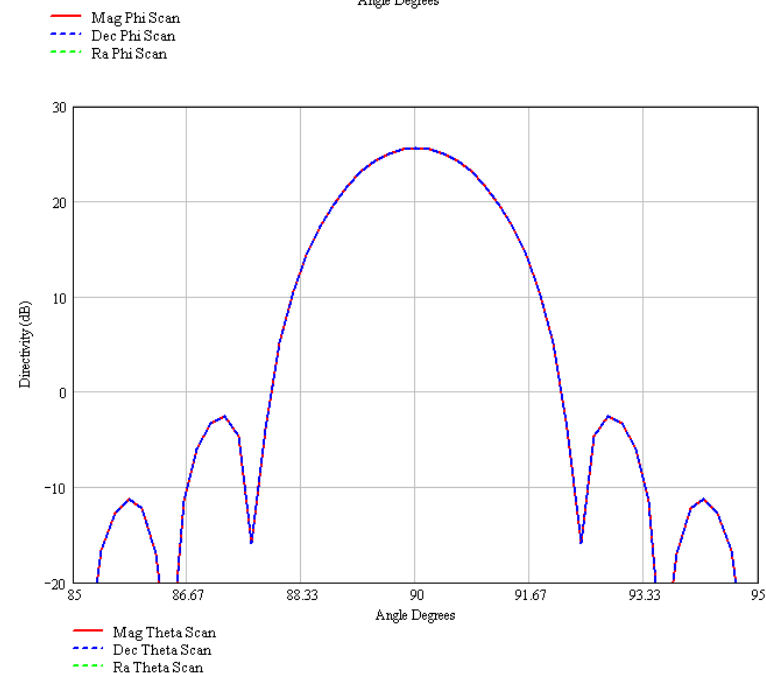# X Polarization (Full Width)

eMagLog

eDecLog

eRaLog

Phi (x)

Theta (y)

Width

Length

0.0
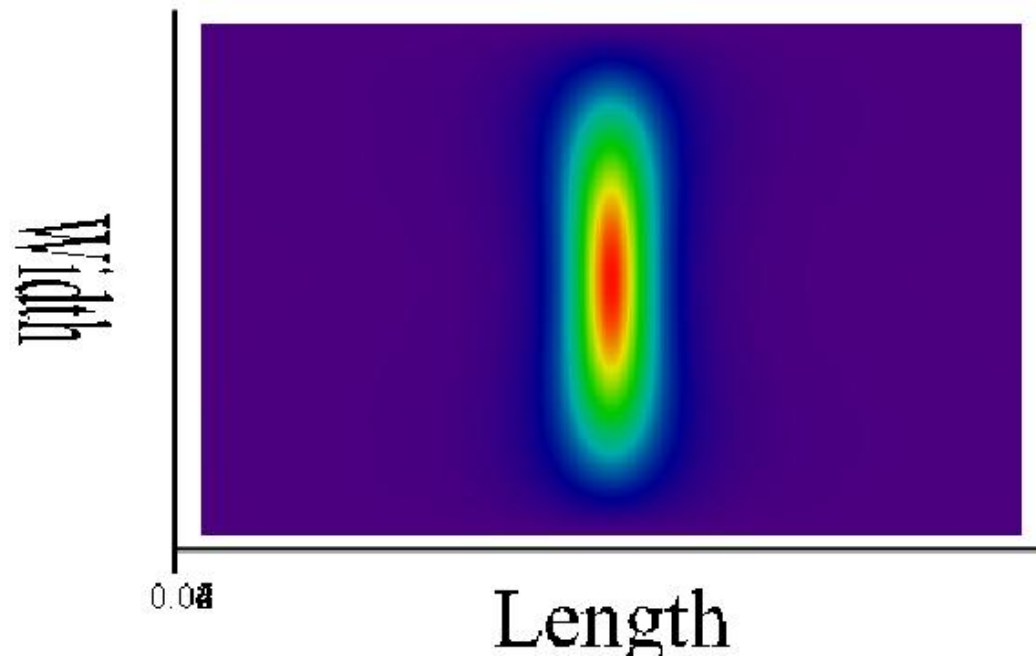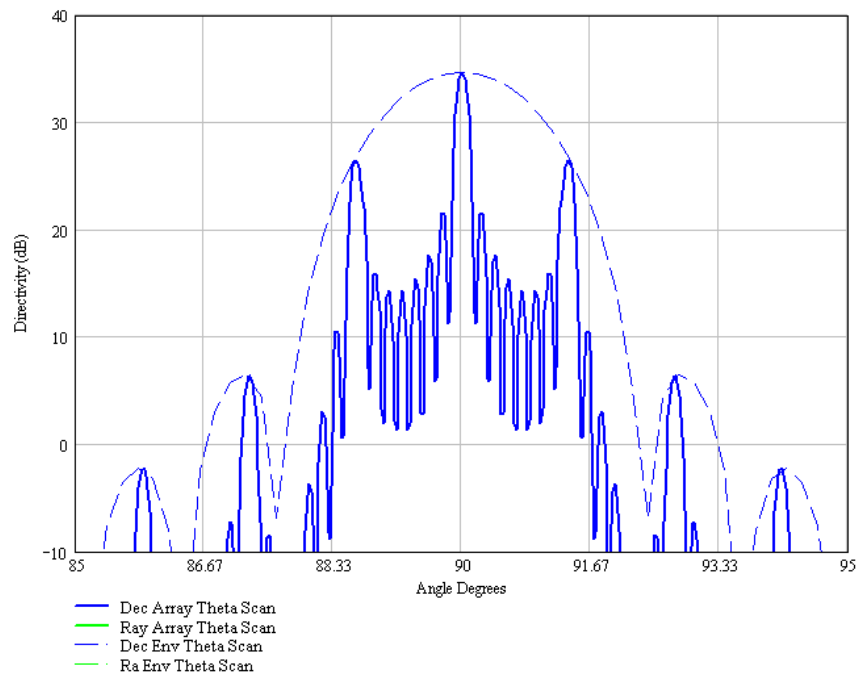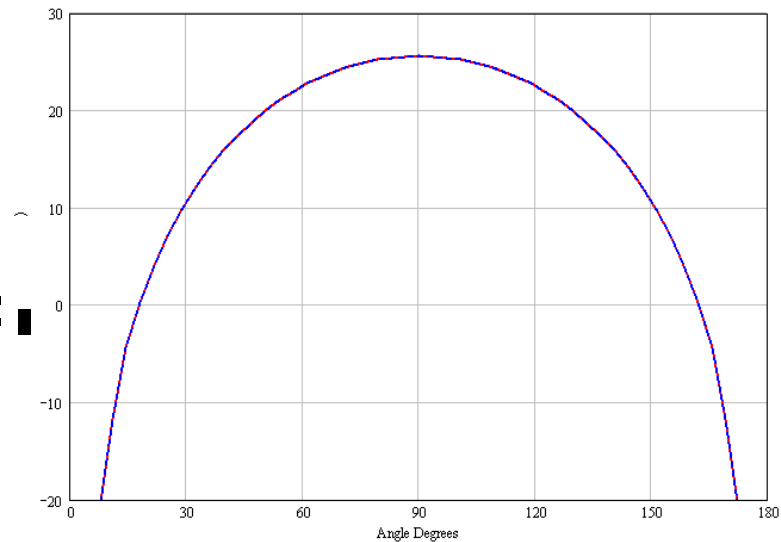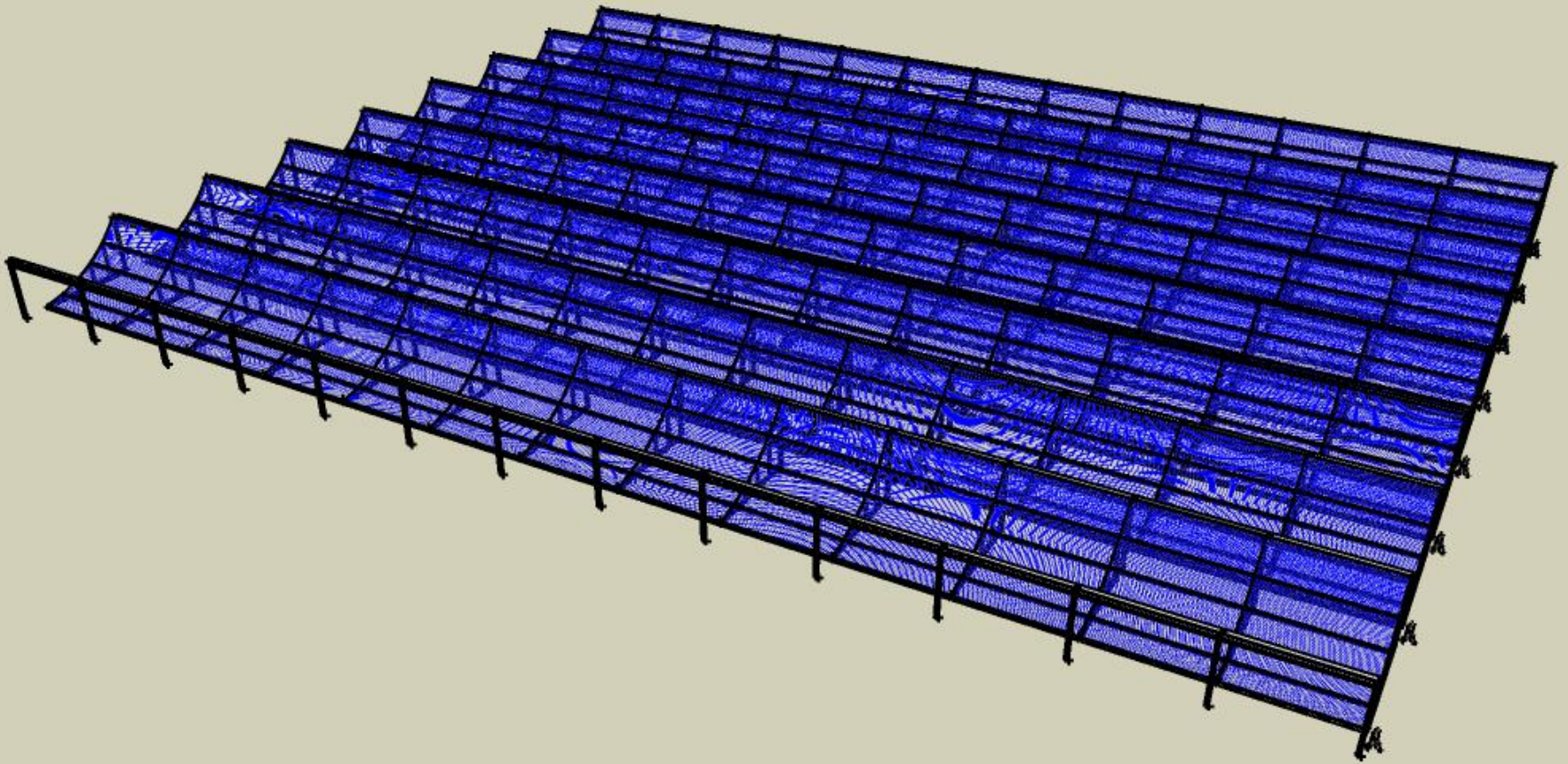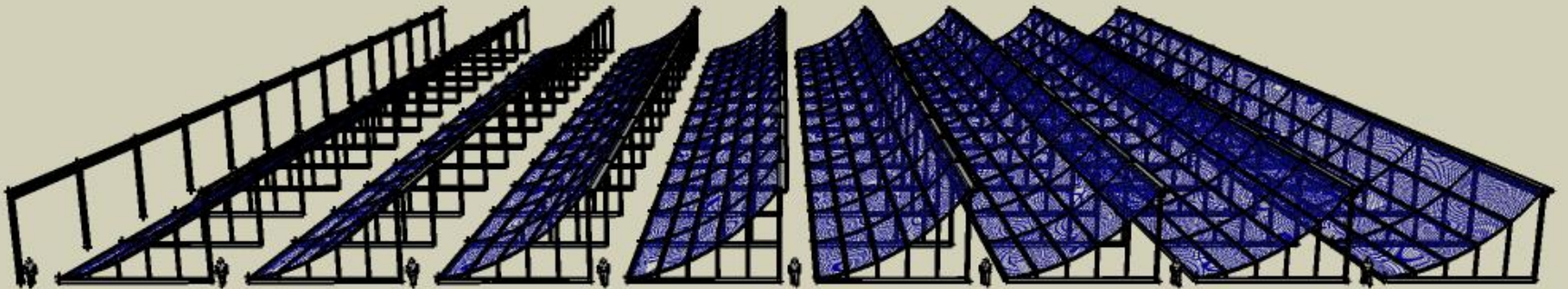
X Polarization (Full Width)
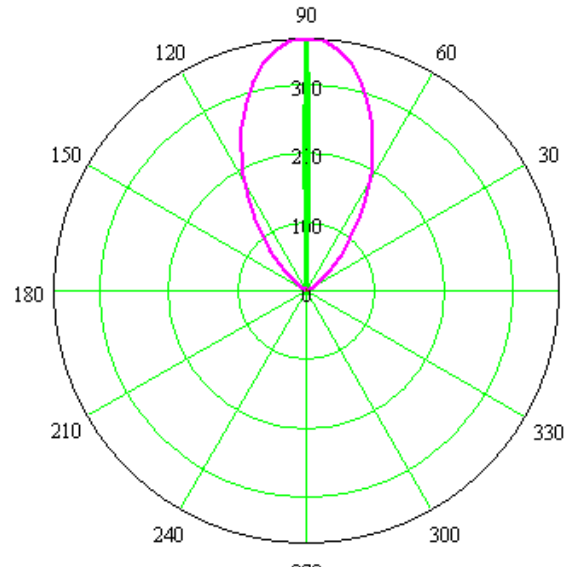
$$\frac{L_{em}}{\lambda} = 0.698$$

Telescope Layout

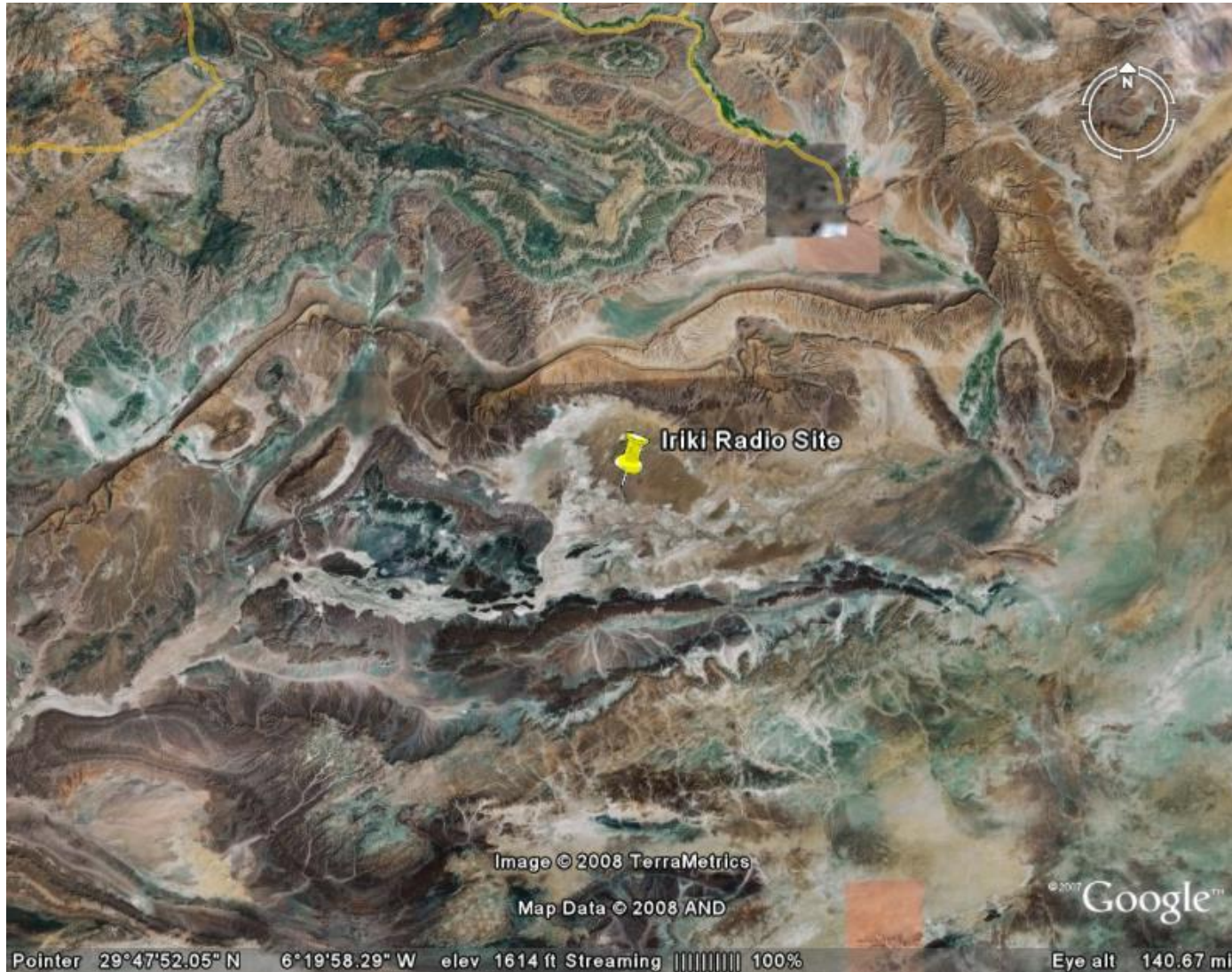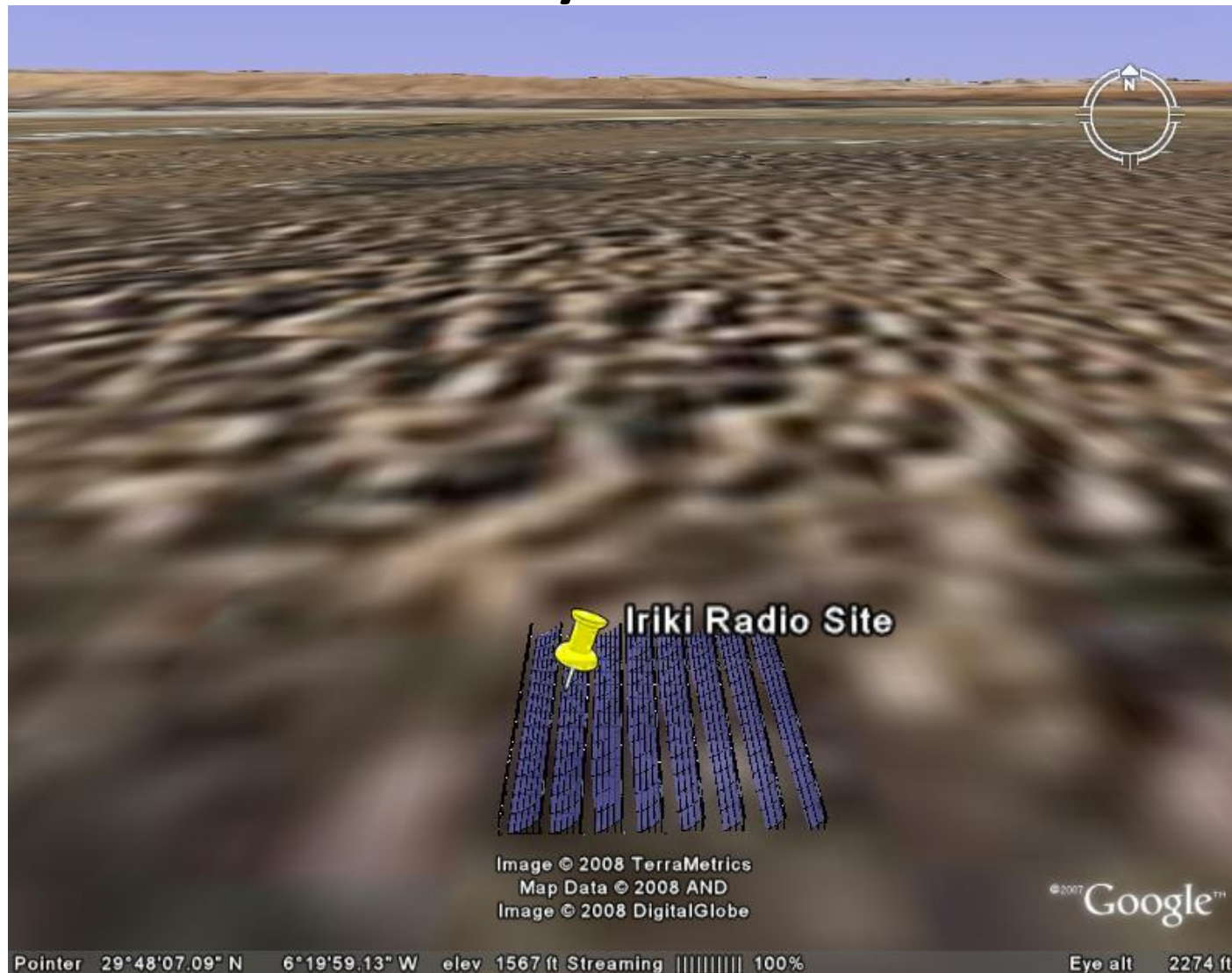# Telescope Layout

Iriki Dry Lake Site

Iriki Dry Lake Site

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Iriki Dry Lake Site

Iriki Dry Lake Site